Saskatchewan
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The White-tailed Deer of the Crystal Beach Game Preserve:

An ecological investigation

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THE WHITE-TAILED DEER OF THE CRYSTAL BEACH GAME PRESERVE: AN ECOLOGICAL INVESTIGATION

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ABSTRACT

General ecological studies were conducted on a population of white-tailed deer inhabiting a 28 km^2 sandhill complex (Crystal Beach Game Preserve) surrounded by agricultural lands. The objectives were to provide an improved understanding of productivity and mortality, condition assessments, movements, and food selection, and thus assist wildlife managers in designing annual harvest strategies for white-tailed deer.

Browse comprised over 84% of the rumen contents from autumn through to spring green-up, after which grasses, legumes and forbs accounted for 75% of the dry weight estimate. Chokecherry, juniper, snowberry and rose were the principal browse species; agricultural crops, including wheat and barley were important grasses utilized. Femur marrow fat percentages declined from early winter levels of 85%, 92% and 90% for fawns, adult females and adult males, respectively, to 31%, 69%, and 52% during late winter. Dependence on browse during the non-green period, in part, contributed to the over-winter decline in condition. During the severe winter of 1973-74 femur marrow fat percentages below 1% were common among all sex and age classes of deer, but adult females fared better than other age and sex classes.

Productivity estimates varied from 1.9 embryos/adult doe in 1973 to 2.1 in 1972, but insufficient data was available on which to base definite conclusions of influencing factors. Animals tagged as fawns and yearlings were responsible for all recoveries beyond 20 km from the study area. Forty per cent of recoveries in these age classes were in excess of 50 km from the preserve and movements beyond 200 km were common. Only 1 of 19 adult tagged deer recovered was beyond 5 km. The sandhill complex studied not only provided important winter habitat for white-tailed deer, but also served as an important production area from which significant numbers of young deer emigrated.

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INTRODUCTION

The white-tailed deer (Odocoileus virginianus dacotensis) is a resource of considerable economic and recreational value to the people of Saskatchewan. During the period 1969 to 1979 inclusive, approximately 64 300 deer licences were issued annually and the mean estimated harvest was 36 400 animals. Deer are more important than any other species of big game for recreational use in the province.

Prior to settlement (pre-1900), white-tailed deer were not common to the aspen parkland of western Canada (Bird 1961), and were most likely restricted to suitable habitat in the creeks and river valleys. At the turn of the century, mule deer (Odocoileus hemionus) were considered to be abundant in both southwestern Manitoba and southeastern Saskatchewan (Baines 1956, cited by Bird 1961, Bird 1961); there is no historical record of significant numbers of white-tailed deer until 1910, but by the 1920's the population in the aspen parklands outnumbered mule deer.

With the advent of land settlement came control of wildfire and a concomitant rapid expansion of woody vegetation. In addition, high moisture levels in the 1940's favoured a further increase of woody vegetation over much of central and southern Saskatchewan, and combined with agriculture, created an interspersion of habitat types ideally suited for white-tailed deer. However, during the 1960's farm practices changed dramatically. Aspen bluffs and shrub patches were cleared from many grain fields, sloughs were drained, and depressions filled. The white-tailed deer population declined as this critical habitat was lost. As early as 1961, Bird states that "intensive mechanized agriculture is rapidly depleting deer habitat, particularly with the use of the bulldozer in land clearing". Then, during the early 1970's, severe winters accentuated the critical nature of habitat losses and winter mortality further depressed the provincial deer populations.

Wildlife biologists throughout temperate North America generally agree that winter is the most critical season influencing productivity and mortality of deer. Ransom (1967) documented relationships between climate and deer productivity in Manitoba. The length of confinement under winter conditions and the time at which new plant growth appears were found to be the most important factors contributing to productivity and mortality of deer in Alberta (Hall 1973). Langenau and Lerg (1976) found winter nutritional stress to result in does rejecting their fawns at birth, and postulated this behavioural syndrome to be an effective form of population control. Verme (1968) developed a winter severity

index for deer in Michigan incorporating wind chill and snow depth components; wind chill was believed to be more important than curtailed mobility. He also believed population density to be an important contributing factor to the condition of wintering deer. More recently, Moen (1978) demonstrated the importance of seasonal influence on the metabolic rhythms of white-tailed deer. He found mid-winter to be the period of lowest energy expenditure, with metabolism increasing as spring approached, and identified the timing of spring as an important factor in population dynamics. Stewart et al (1977) arrived at similar conclusions regarding the importance of spring as part of a moose ecology study in Saskatchewan.

To properly manage the resource, Saskatchewan wildlife officials recognized a need for an "annual plan" for white-tailed deer management. This plan required initiation of field research studies designed to improve the managers' knowledge of white-tailed deer biology in Saskatchewan.

Gatehouse (1970) outlined a study of deer wintering in the Crystal Beach Game Preserve (CBGP) with the following objectives:

1. To assess the progressive decline in the physical condition of white-tailed deer during the winter "yarding" period.
2. To determine the annual winter population and to obtain an estimate of winter mortality.
3. To document the extent of annual variation in reproduction and to isolate the factors contributing to it.
4. To determine the extent of surrounding summer habitat required to isolate factors contributing to movements into and away from winter habitat.

The objectives of the study were expanded in 1972 to include a detailed investigation of the diet of deer on their "winter range".

This report represents the synthesis of data collected by the late Steve Gatehouse between 1969 and 1971, Wayne Runge between 1971 and 1976, and the senior author from 1976 to 1977 on the ecology of white-tailed deer inhabiting the CBGP near Harris, southwest of Saskatoon.

STUDY AREA

The study area, comprising 28 km^2, is located within the CBGP, 72 km southwest of Saskatoon (Figure 1). The area, an island of treed habitat surrounded by wheat farms, traditionally has a high winter population of white-tailed deer, and was therefore designated as deer "winter range" (pers comm., Wayne Runge, Department of Parks and Renewable Resources, Prince Albert, Saskatchewan). Situated within the broad Dark Brown soil zone of central Saskatchewan (Moss 1965), the Preserve is classified as an aeolian landform with sand dune topography surrounded by a fine sandy loam soil complex (Ellis et al 1968).

The CBGP lies within the Cold Steppe Climate (Richards and Fung 1969) where evaporative loss of water often exceeds precipitation and semi-arid conditions prevail. Mean annual precipitation is 32.6 cm, one-third falling in the form of snow.

Vegetative patterns throughout the area are influenced by extreme variation in local site moisture and exposure. Sites prone to wind erosion are characterized by species such as Indian rice grass (Oryzopsis hymenoides), Canada wild rye (Elymus canadensis), hairy golden-aster (Chrysopsis villosa), narrow-leaved psoralea (Psoralea lanceolata), cactus (Opuntia polyacantha) and various other forbs. On more established sites, sun-loving sedge (Carex heliophila), wheat grasses (Agropyron spp.) and spear grass (Stipa comata) are common. Spear grass, June grass (Koeleria cristata), wheat grass and blue grama (Bouteloua gracilis) form the grassland community on the remainder of the native area and on stabilized sand dunes.

Shrubs common to stabilizing dune blow-outs include creeping juniper (Juniperus horizontalis), common juniper (Juniperus communis), bearberry (Arctostaphylos uva-ursi), and rose (Rosa spp.). Throughout most of the CBGP, snowberry (Symphoricarpos occidentalis), silverberry (Elaeagnus commutata), chokecherry (Prunus virginiana), and saskatoon (Amelanchier alnifolia) are prevalent. Groves of aspen (Populus tremuloides) are common in low-lying areas.

Marginal grain farming operations exist on the periphery of the study area and sporadic attempts have been made to cultivate the light sandy soil on the flats between the sand dunes. The flats occupy about 40% of the area, the remainder being the hilly dunes. Livestock are grazed throughout the study area during spring, summer and autumn, and a small herd of horses inhabits the area year-round.

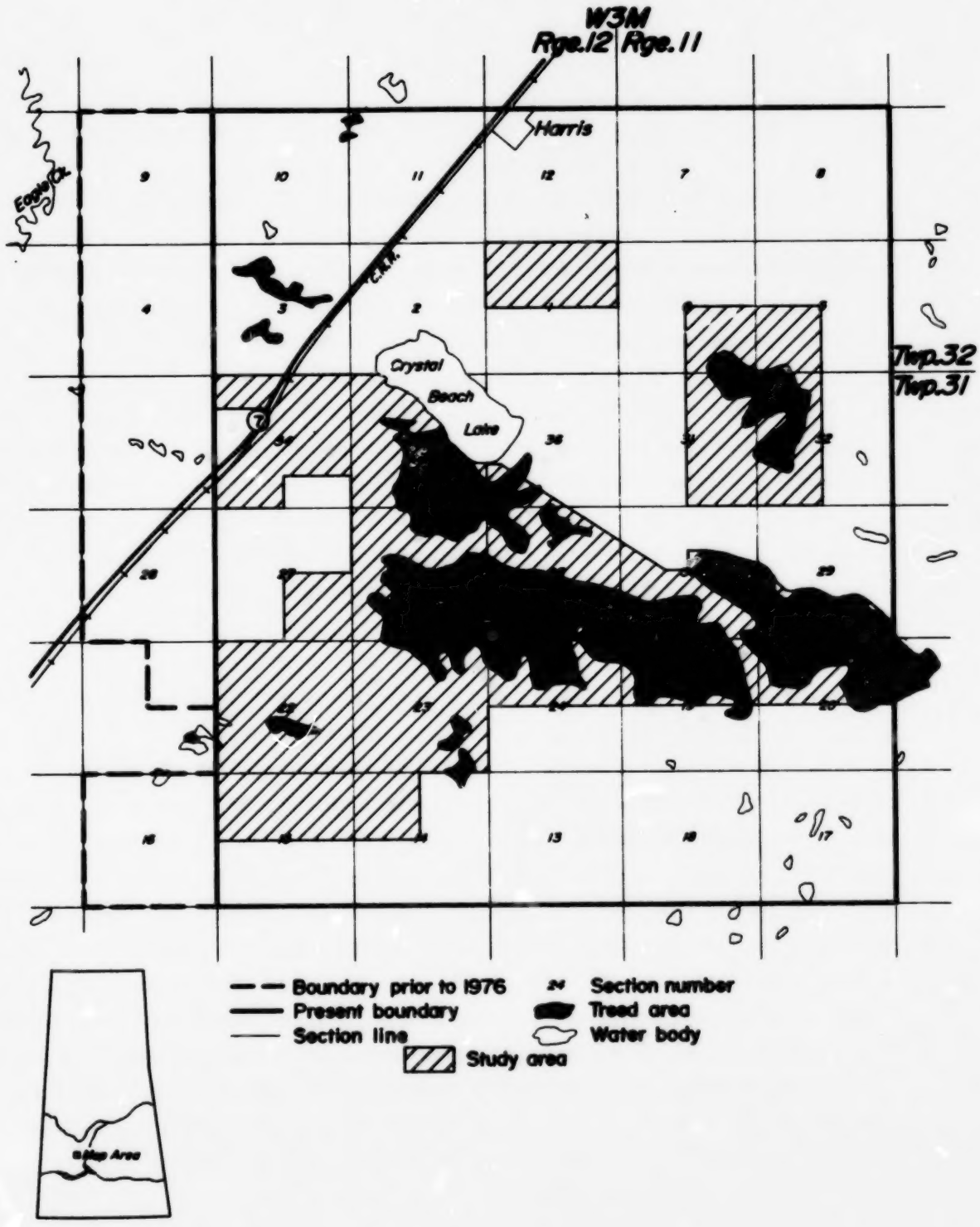

Figure 1. Location of the Crystal Beach Game Preserve and the study area.

METHODS

a) Population Estimates

Since 1969, aerial surveys have been conducted within the CBGP to provide data for estimation of the size of the winter deer population. Surveys were conducted between January and April each year, flown in a Cessna 172 aircraft at an airspeed of 128 km/hr and 120 m altitude. Two observers, one on each side of the aircraft, recorded deer observed within 195 m of their side of the plane. Prior to 1972, 100% coverage was achieved on 41 km^2, but during 1972 transects were situated at 780 m intervals to provide 50% aerial coverage of the study area which then included 47 km^2. Following 1972, density estimates were based on deer observed on 100% aerial coverage surveys flown within a 28 km^2 block of treed habitat (Figure 1). For this report, only deer observed within that core of habitat were used to calculate winter population density estimates during all years of the study (1969–77). Runge (1972) believed a minimum of 35% more deer inhabited the area than were observed; all density estimates include this correction factor.

b) Deer Movement Study

A deer movement study was initiated during the 1972 winter to determine the extent to which deer wintering within the study area used surrounding habitat during the summer. Between January and April from 1972 to 1974, deer were trapped in baited box traps, ear-tagged, aged, sexed and released, using a technique similar to that described by Runge (1972) for deer trapped in southeastern Saskatchewan. Plaster cast positives made from molded impressions of the teeth of trapped deer, a technique described by Flyger (1958), were used for estimation of age by the wear class patterns reported by Severinghaus (1949). Those marked deer which fell victim to hunter harvest, winter mortality, trap death, and automobile or train collisions provided recovery data. Locations of mortalities were plotted, and whenever possible, lower jaws were collected for age estimations.

c) Range Condition

Transects were established on the study area in the spring of 1970 to assess browse availability and condition. A total of 450 random plots, each 0.4 m^2, were evaluated by the key browse survey method described by Cole (1959).

Key browse species included aspen, chokecherry, and saskatoon. They were estimated to be lightly, moderately, or severely hedged based on the length and appearance of the previous year's growth below current leaders. The key browse species in each plot were assigned to one of the following classes:

Seedlings — plants with stem diameters of less than 0.3 cm
Young -- plants with a stem diameter between 0.3 and 0.6 cm
Mature — plants with a stem diameter greater than 0.6 cm
Decadent — plants with a 25% or greater crown area dead

Estimates of availability were based on all plants to a height of 1.5 m. Plant components above this height were considered unavailable for browsing by deer.

The number of available stems per hectare was also recorded for snowberry, rose and silverberry. Estimates of abundance of juniper and bearberry were judged on the per cent ground cover of each species in the plots.

For analysis, those plots which fell in the flats and hills were treated independently, as well as together, to yield separate and overall estimates of availability.

d) Weather

As previously stated, winter climate is a major limiting factor to deer populations in the north temperate environment. Factors considered of importance included wind chill, snow depth and duration of the winter period. Stewart et al (1977) demonstrated the potential effect the timing of plant phenological events may have on the energy balance of moose, and a similar concept has been incorporated into the present investigation. In that study, the time between woody vegetation leaf flush in the spring and leaf drop in the fall was considered the green period of positive energy balance for the animal. For the present investigation, the green period ideally would be based on the length of time during which green grass and forbs are available, but no work has been published on the

heat requirements for grass and forb shoot growth in the spring; for this reason, the results of this investigation are based on woody shrub leaf flush requirements. The reader should be aware that the green period for grasses and forbs would be extended beyond that reported for shrub and tree vegetation. Indices of degree of annual severity for each of wind chill, snow depth, and duration of the winter season are developed to facilitate our understanding of their influence on mortality and productivity of white-tailed deer.

The wind chill index was based on a yearly summation of daily wind chills (October to April) according to Siple and Passel's (1945) formula which combines the effects of mean daily temperature and wind speed on the cooling rate of a body at a neutral skin temperature of 33°C. When the dry cooling rate is less than the rate of body heat production, excess heat is removed by vapourization. The cooling rate was developed for exposed human flesh; however, as all estimations are of numerical values which are used to describe a relative severity of wind chill, the technique provides a relative comparison of annual variations in the severity of wind chill. These values should not be construed as a measure of physiological heat loss by white-tailed deer during winter. Age of animal, season, habitat, and behaviour all influence the empirical measure of animal heat loss, variables which are beyond the scope of this investigation. Monthly wind chill totals were plotted graphically and the points joined. The area under the line connecting these monthly estimations was used as the wind chill index for each year.

The snow depth index was developed according to the technique described by Coady (1974), but instead of using month end snow depths, a monthly mean snow depth was determined. The monthly mean snow depths (October to April) were plotted on a graph and the points joined. The area under the line was used as the snow depth index for each year.

The energy index calculation was based on the method described by Stewart et al (1977) in their discussion of moose in east-central Saskatchewan. The concept of the growing degree-day which postulates that a plant requires a definite number of heat units in order to reach certain stages of development (Boughner 1964) was employed to establish green period initiation (leaf flush) dates. Termination of the green period was defined to be that date when ambient temperatures dropped to -5°C or lower. Levitt (1956) and Larcher (1973) agreed that mean minimum temperatures of -5°C were required to cause leaf cellular destruction (lysis) and thus leaf fall. The number of days between leaf flush and leaf fall comprises the period of positive energy balance, while negative balances are

based on the number of days woody vegetation was devoid of available green foilage. An index based on the ratio of the number of days woody vegetation was devoid each winter to the number of days leaves were available the previous summer for the year 1969-70 to 1976-77 is presented for the CBGP.

Spearman's coefficient of rank correlation (Steele and Torrie 1960) was used to test the relationship between mortality, and the indices of wind chill, snow depth, energy and population density.

e) Body Condition Assessments

Assessments of the condition of white-tailed deer were based on analysis of kidney fat indices and per cent femur marrow fats determined for 124 and 122 animals, respectively, collected between October and April for the years 1969-70 and 1972-73, inclusive.

The kidney fat index (KFI) is the ratio of the weight of kidney-associated fat to the weight of the kidney (McGillis 1972). Results of the analysis were used to assess rates of overwinter depletion of kidney fat for deer on the study area.

The right femur was removed from each carcass. A fresh central section of marrow was removed, weighed, freeze-dried, and then reweighed to yield an estimate of moisture content. The freeze-dried sample was then subjected to ether extraction to determine fat content by the Feed Testing Lab, Department of Animal Science, University of Saskatchewan, Saskatoon. The per cent marrow fat of the fresh sample is obtained from the following formula:

$$\frac{\text{(Fresh Sample-Moisture Content) (\% Fat Content of Dried Marrow)}}{\text{(Fresh Sample Weight)}} \times 100\%$$

f) Reproduction

Reproductive tracts from does were collected between January and April in each of 1970 (n=19), 1972 (n=21), and 1973 (n=19) to assess age-related differences in ovulation rates and number of embryos produced. Ovaries were sagittally sectioned into 1 mm segments and ovulation rates were determined by the number of corpora lutea of pregnancy present therein. Embryo survival rates were determined by comparing the number of observed embryos to the number of corpora lutea of pregnancy.

g) Mortality

Estimates of deer winter mortality have been obtained annually since April 1970. A technique described by Severinghaus (1961) in New York State was used, whereby individuals walk a known linear distance and search within a few metres on each side of a median line for carcasses. Total area searched in 1970 was only 1.3 km^2. The area was expanded to include 5.2 km^2 from 1971 to 1973 and 10.4 km^2 thereafter. Sighting distances or distances from the line of travel for recovered carcasses were not considered.

h) Seasonal Diets

Identification of food items consumed was determined for 95 white-tailed deer collected between February 1970 and April 1973. One-quart aliquots of rumen material were washed through sieves, separated according to species, and oven dried over night at 75°C. Each component was then weighed to 1 mg accuracy and per cent dry weight determinations were calculated. Frequency of occurrence was also noted for each plant species. Data is presented as an aggregate rumen sample (Martin et al 1946).

For comparative purposes, each rumen sample was allotted to one of four seasons:

Autumn — post-leaf fall to early winter (mid-December)
Winter — mid-December through to break-up (snowfall no longer restricts movement away from the preserve)
Break-up — little or patchy snow to green-up
Green-up — period when fresh green vegetation first appears in rumen samples to early May

The estimated date for each season interval varied from year to year, depending on prevailing weather conditions.

RESULTS AND DISCUSSIONS

a) Population Density Estimates

Estimates of white-tailed deer densities were highly variable, ranging from 3.8 deer/km^2 in March 1971 to 16.8 deer/km^2 in March 1969 (Table 1). The estimates generally declined between the January and March-April surveys, but not at a constant rate. Factors which affect survey accuracy may be significant during the latter part of winter. Evans et al (1966) reported visibility bias on linear strip transects to significantly affect moose observations between any two flight periods; good snow cover was practically essential. Cook and Martin (1970) described visibility error as "the main cause in inaccurate aerial census data and, depending on various contributing environmental factors (eg. snow cover, weather, observer fatigue, and terrain) can produce severely biased population density estimates". Jacobson and Weatherill (1975) stated, "Development of a successful long-term aerial census program for white-tailed deer will require the identification of as many of the visibility variables as possible, a rigid quality control procedure to hold these variables within predetermined bounds of acceptability on all censuses, and establishment of a comprehensive data base from which to analyze the statistical contribution of each variable to the census results". Jacobson et al (1975) found afternoon-only counts to yield more than 2.5 times the number of deer observed during morning-only counts on high and medium deer density quadrants in Manitoba.

Aerial survey conditions were not ideal for all surveys conducted during this investigation. Extremes of snow depths and temperatures prevail during January surveys, while most late winter (March-April) surveys were conducted during patchy or snow-free conditions. Visibility bias would therefore be expected to affect late winter estimates to a greater extent than those obtained in January. In addition, movements of deer away from the preserve during the later period must also be considered important. One can appreciate the caution which should be exercised when drawing inferences from survey data collected over several years and under varying circumstances.

b) Deer Tagging - Movement Study

The sample of 192 live-trapped deer consisted of 52% fawns, 19% yearlings and 29% adults (Table 2). The sex ratio for fawns, yearlings, and adults was 85, 275, and 49 males/100 females respectively. The high proportion of yearling males is attributed to a

Table 1. Population density estimates (animals/km^2) of white-tailed deer on the study area.

Year	January	February	March	April
1969	-	-	16.8	-
1970	14.3	-	-	-
1971	6.1a	-	3.8	-
1972	8.6	-	5.6 9.3b	-
1973	8.7	-	5.8	-
1974	6.0	11.8	-	7.4
1975	9.8	-	6.2	-
1976	11.2	-	-	-
1977	9.1	-	-	-
1978	11.7	-	-	5.3c

a Survey includes only 15.6 km^2 due to bad weather

b Survey flown twice during March 1972

c Survey flown by helicopter April 21 just prior to leaf flush

Table 2. Age ratios of deer live-trapped on the study area, 1972-1974.

Age in Years	1972	1973	1974	Total
Fawn	37(60%)	42(60%)	20(33%)	99(52%)
1 3/4	11(18%)	12(17%)	13(22%)	36(19%)
2 3/4	3(5%)	5(7%)	10(17%)	18(9%)
3 3/4	4(6%)	2(3%)	9(15%)	15(8%)
4 3/4	2(3%)	3(4%)	4(7%)	9(5%)
5 3/4+	5(8%)	6(9%)	4(6%)	15(7%)
TOTAL	62	70	60	192

differential vulnerability to capture; several authors have established this differential for vulnerability to hunter harvest (Hawkins et al 1971, Silver et al 1968).

During 1974, a lower proportion of fawns were captured than in each of 1972 and 1973. The 1974 winter was the most severe with respect to wind chill and snow depth, and had a high negative energy index (Appendix 1). The mortality rate exceeded 4.3 deer/km^2 or 36% of the winter population (Table 3). Of all animals found dead in the spring of 1974, greater than 53% were fawns. Fawns comprised only 33% of deer trapped in 1974, compared to 60% in each of 1972 and 1973, a difference which was highly significant (χ^2 = 11.61***).

Thirty-seven per cent of the deer tagged were subsequently killed or found dead, providing information on the location and date of death (Figure 2). Hunter harvest accounted for 65% and winter mortality 26% of the retrieved marked deer (Figure 3).

The mean recovery distances for each sex and age class of deer are given in Table 4. All fawns retrieved died from starvation and were located within the study block. Among those animals tagged as fawns or yearlings in the winter but not recovered at least until the following autumn, more than 30% of these animals were more than 50 km ($\bar{x}$ = 215 km) from the CBGP. In contrast, only 1 of 19 deer tagged as adults were recovered more than 5 km from the capture site (Table 4). Most adult deer recovered were found dead within the study area during spring searches for winter killed animals. Thirty-two per cent of the tagged adult females and 37% of the tagged adult males were recovered.

Students of deer ecology generally agree winter cover is an important ingredient for survival of the species in a northern environment. Moen and Severinghaus (1981) suggested that deer living in exposed areas have a more difficult time keeping up with heat loss than deer wintering in sheltered areas. Many authors have also indicated deer may behave as a migratory species with distinct winter and summer ranges (Harmoning 1976); others have argued that young male white-tailed deer are the main emigrating component of a herd but that bucks may take up permanent residency in areas established as yearlings (Hawkins and Klimstra 1970). Shoesmith and Bidlake (pers. comm., Department of Natural Resources, Winnipeg, Manitoba) working in southwestern Manitoba observed some deer populations to be very mobile and others to be relatively

Table 3. Winter population size and mortality estimates for white-tailed deer on the study area, 1970 - 1977.

Year	POPULATION ESTIMATES			DEAD DEER SURVEY		
	Month of Survey	Winter Population	Density/km^2	Date	Estimated Mortality/km^2	Percent Mortality
1970	January	407	14.3	April 21	6.9	48.2
1971	January	174	6.1	April 15	2.5	40.1
1972	March	265	9.3	April 28	1.2	12.9
1973	January	248	8.7	April 11	1.5	17.2
1974	February	336	11.8	May 3	4.2	35.6
1975	January	270	9.8	April 30	1.8	18.4
1976	January	319	11.2	April 20	0.8	7.1
1977	January	259	9.1	April 19	0.7	7.7

* Population estimate based on highest winter survey density

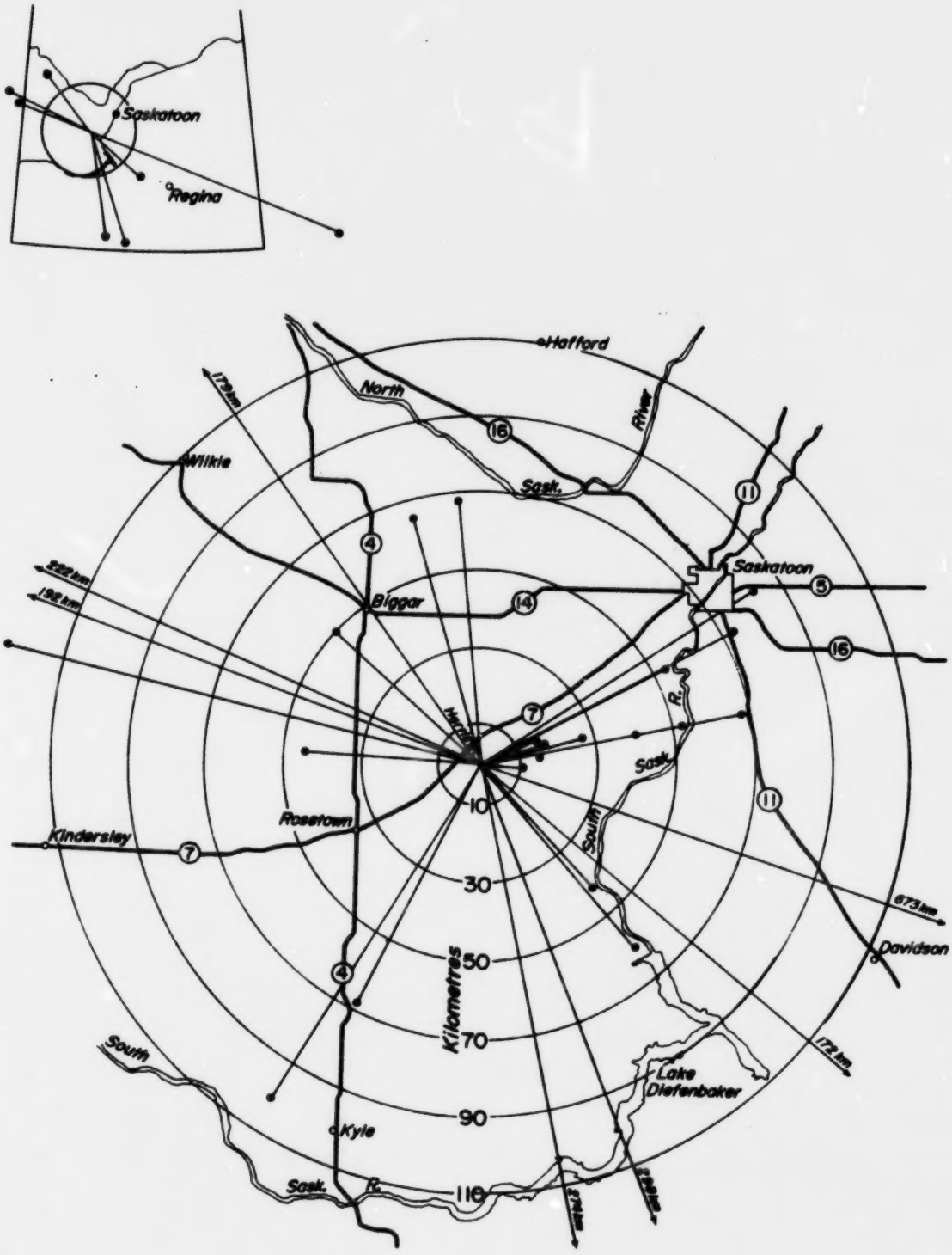

Figure 2. Direction and magnitude of movements of white-tailed deer tagged on the study area.

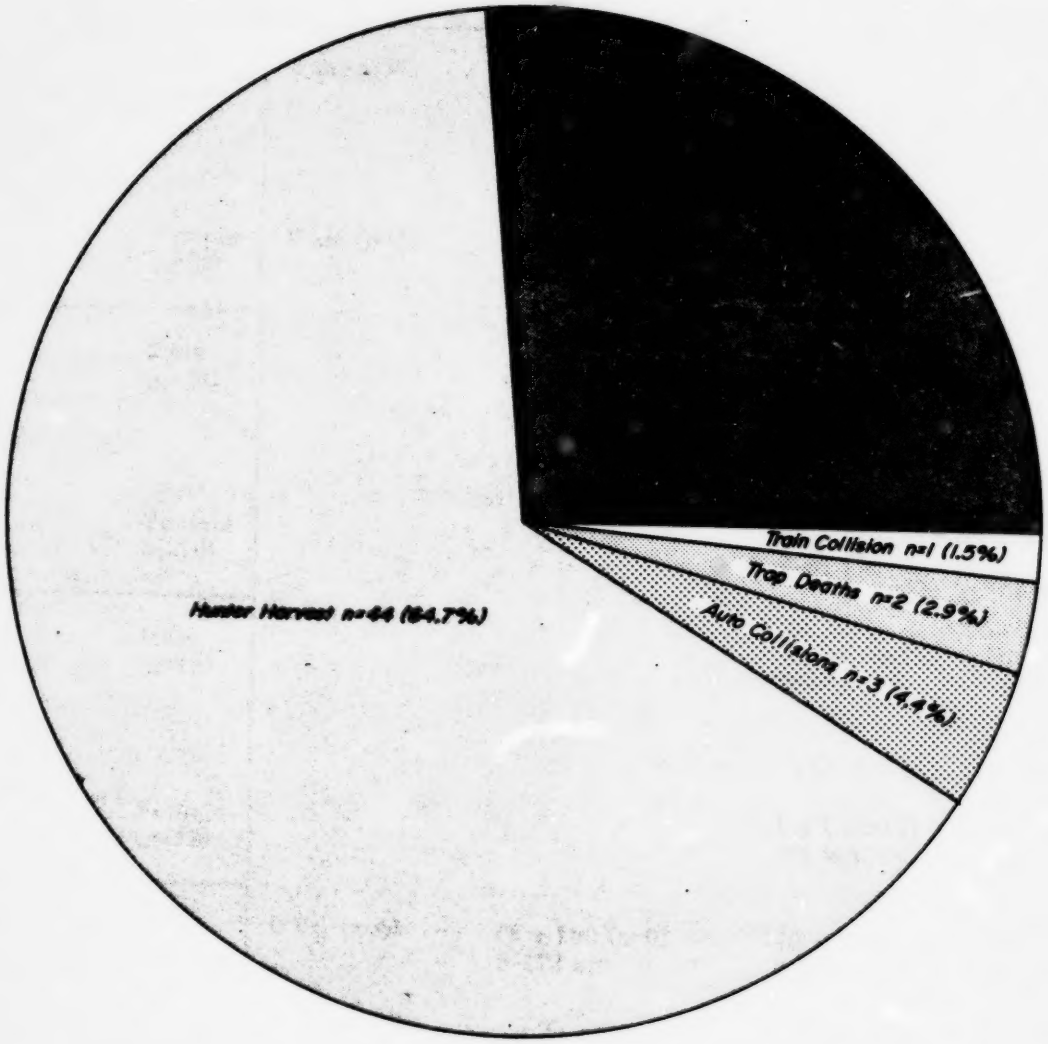

Figure 3. Causes of mortality for white-tailed deer tagged on the study area.

Table 4. Recovery distance ($\bar{X}$ ± 1 S.D.), range, and percent recovery for white-tailed deer tagged on the study area.

Sex and Age When Tagged		Age When Recovered			
		Fawn	Yearling	Adult	Percent
Fawn (n=99)	Male (n=46)	0 km (n=6)	56 ±100 (n=9) 0-273 km	93 ± 112 (n=6) 0-298 km	46
	Female (n=53)	0 km (n=3)	200 ± 277 (n=5) 0-673 km	23 ± 23 (n=8) 0-72 km	30
Yearling (n=36)	Male (n=26)			52 ± 73 (n=10) 0-192 km	38
	Female (n=10)			26 ± 28 (n=5) 0-67 km	50
Adult (n=57)	Male (n=19)			5 ± 11 (n=7) 0-30 km	37
	Female (n=38)			1 ± 1 (n=12) 0-5 km	32
Total (n=192)	Male (n=91)	0 km (n=6)	56 ± 100 (n=9) 0-273 km	48 ± 79 (n=23) 0-298 km	42
	Female (n=101)	0 km (n=3)	200 ± 277 (n=5) 0-673 km	13 ± 21 (n=25) 0-72 km	33

sedentary; most long-range movements observed involved young males. In one area of forested habitat they concluded that the deer population had both a dispersing and sedentary component and observed some long-range movements (up to 51 km) among dispersing animals.

The deer inhabiting the Crystal Beach study area provide an additional facet to the understanding of deer movements. It is our contention that the forested habitat block within the CBGP serves both as an important production and wintering area for deer. The deer population appears to consist of sedentary and emigrating components. The resident population consisted largely of adult animals; fawns and yearlings accounted for the mobility of the population.

The extent to which deer utilize habitat surrounding the Preserve has not been documented, but little habitat is available to support significant numbers of animals. The spring fluctuations in population estimates may be explained in part by juvenile emigration, juvenile and adult movements for short distances outside the study area, and the poor survey conditions which predominate during this season. These condition differences exist on an annual basis and as such, a consistent decline in density estimate results between January-February and March-April survey periods each year ($r=0.99$).

A survey conducted by helicopter on April 20, 1978, just prior to green-up, yielded a population estimate of 152 white-tailed deer. This was 45 per cent of the total number of animals observed during the annual deer survey during January with a fixed-winged aircraft, but was consistent with the rates of decline observed between mid and later winter surveys in other years. The comparison of estimates may be in question owing to the differences in aircraft and season, but the fact that a significant number of deer appear to remain within the confines of the CBGP cannot be disputed. The higher winter populations may be explained in part by the addition of a new fawn cohort combined with a return to the area of deer inhabiting suitable summer habitats outside the Preserve.

c) Food Selection and Availability

The existence of a positive seasonal relationship between white-tailed deer and their use of agricultural land surrounding the forested habitat core was reinforced by information collected on season diets. Browse items composed the bulk of the rumen material sorted from samples collected autumn through to spring break-up (Figure 4, Appendix 2). By green-up, grasses were the major components of the food items. Forbs accounted for a minor proportion of the total dry weight of the aggregate rumens each season.

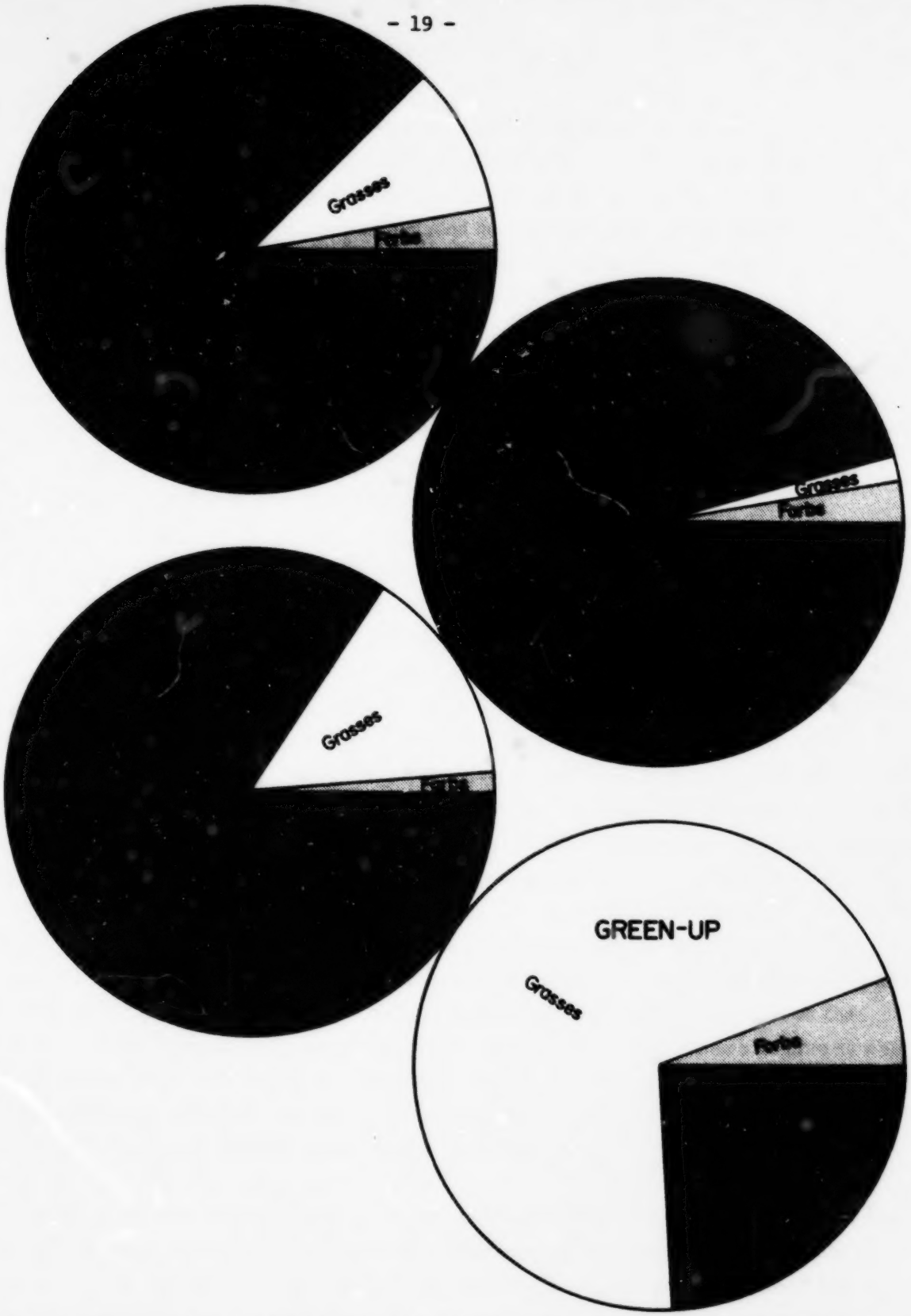

Figure 4. Summary of seasonal food selection by white-tailed deer from the Crystal Beach Game Preserve, Sask., based on analysis of rumen contents (February, 1970 to April, 1973).

Chokecherry, rose, silverberry and snowberry were utilized most during the fall and early winter. As winter progressed, ground shrubs (juniper and bearberry) became important to the deer diet; snowberry, chokecherry and aspen twigs were also common early and late winter browse items. Saskatoon berry which was included in the key browse species analysis did not constitute a significant portion of rumen material sorted, and as such was not considered to be an important browse item for white-tailed deer on the Harris Game Preserve.

The utilization of grasses following snow melt (break-up) and throughout the period of green-up was not restricted to vegetative plant components. Wheat and barley seeds accounted for most of the classified grass material at break-up, with vegetative plant material comprising only 2.5%. However, during green-up, green vegetation accounted for 37.1% of rumen material weight. Cereal grain seed remained a major dietary component at this time.

Based on species availability, the results from the rumen analysis are expected. Snowberry accounted for 64% of all available stems on the study plots, followed in abundance by chokecherry and rose (Table 5). Juniper and bearberry were both common ground shrubs covering 4.4% and 1.9% respectively of the ground area (Table 6). In addition, those species designated as "key browse species" during the experimental design, apparently were subject to heavy rates of utilization, based on the extent of hedging and decadence recorded. Over 55% of the chokecherry and 48% of the saskatoon plants were estimated to be severely hedged; 55% of the former and 38% of the latter were classed as decadent. Hedging and decadence were 15% and 25% respectively for aspen. Saskatoon was the only one of the eight browse species subjected to availability estimates which did not appear to be a major component of the rumen browse items in any season. Thorpe (1978) studied cattle-big game competition in the Bronson Forest in west-central Saskatchewan and identified saskatoon as a high preference browse species for cattle. Rock (1980), working in the same area, observed a decline in availability and production of saskatoon with increased grazing pressure. Similar activity by cattle on the CBGP would result in a displacement of deer from areas where saskatoon was available as well as contribute to the severe hedging and decadence observed for this species such that it would essentially be unavailable for deer use. Chokecherry and juniper were commonly selected browse items for three of the four seasonal divisions (Appendix 2).

The high incidence of severe hedging and decadence observed for chokecherry may reflect the dense deer population (14.3/km^2) estimated to be wintering on the study area during 1969-70. Unfortunately, habitat assessments were not continued following the 1969-70 winter. The condition of the range must be considered a vital component of deer ecology, and may have a significant influence on productivity and overwinter mortality. Dasmann (1971) believed food to

Table 5. Stems/ha and percent of all available stems for each species in two habitat types on the study area (Fall 1970).

Species	No. of Stems/ha Available			Percent of All Stems		
	Flats	Hills	Overall	Flats	Hills	Overall
Chokecherry	3 408	16 178	11 065	3.8	19.1	12.8
Aspen	1 086	3 656	2 618	1.2	4.3	3.0
Saskatoon	2 865	1 630	2 124	3.2	1.9	2.5
Snowberry	59 280	52 858	55 328	66.8	62.5	64.2
Rose	14 079	8 398	10 621	15.8	9.9	12.3
Silverberry	8 077	1 902	4 372	9.1	2.2	5.1

Table 6. Percent ground cover of juniper and bearberry on the study area, Fall 1970.

	Percent Ground Cover		
	Flats	Hills	Overall
Juniper	1.4	6.4	4.4
Bearberry	1.8	2.0	1.9

be the weakest point in the "food-water-cover" triangle. Overbrowsing, which results in decreased plant vigor and reduced forage production, makes the herd more susceptible to drought, severe winters and disease. The possible influence of range plant condition on the deer population wintering on the study area during 1969-70 is open to speculation. Any future research programs of this nature should be designed to quantify range condition, especially on islands of habitat known to sustain large annual and/or seasonal fluctuations in deer use.

Dasmann (1971) stated in a review on deer food habits: "The important thing to remember about deer preference ratings is their variability. Even in one locality they may vary with the season of the year, the growth stages of the plants, and the changing composition of plant cover. A plant species that is heavily used in one place may be ignored in another place or at another time". All major food items utilized by deer on the CBGP have been reported in other investigations (Dasmann 1971, Nixon et al 1970). The results of a deer rumen composition study for deer collected from southeastern Saskatchewan in 1966 indicated significantly more use of agricultural crops during fall, winter, and spring (Stewart 1981). However, deer inhabiting the southeast were not confined to an island of habitat and had good access to agricultural lands throughout much of the winter.

d) Mortality and Productivity

The growth and stability of animal populations is highly dependent upon the balance between productivity and mortality. Those variables which can affect this balance in animal populations have been segregated as to whether their effects are intrinsic (density dependent) or extrinsic (density independent). For the present investigation estimates of population density and its influence on mortality were considered a density dependant factor while weather (windchill, snow depth, duration of winter) variables were classified as density independent.

To document the progressive decline in white-tailed deer fat reserves throughout winter, data was obtained for estimations of the kidney fat index and per cent femur marrow fat; overwinter declines of kidney and marrow fat were observed in all deer measured for these factors. Moen and Severinghaus (1981) found deer to lose weight during winter even on adequate diets and that seasonal weight fluctuations are characteristic of the normal annual cycle. However, he also found differences in the weight curves of deer from different areas to be related to levels of adequate nutrition. Ransom (1965) compared the kidney fat index to femur marrow fat percentages and found the KFI to be a poor indicator of marrow fat percentages once the KFI dropped below 30. These findings were substantiated by Runge (pers. comm., Department of Parks and Renewable Resources, Prince Albert, Saskatchewan) for white-tailed deer in Saskatchewan.

Males tended to utilize kidney fat much earlier than females and fawns (Figure 5a, 5b), owing to increased activity and reduced food consumption characteristic of the rutting period. Major declines in the KFI for fawns were not obvious until after January when levels dropped to below 30. The largest decline in the femur marrow fat for this class was not experienced until after March when levels declined from about 70% to 50%. The pattern of fat catabolism was similar for female deer, but femur marrow fat percentages did not generally decline below 70% for the collection periods between 1969-70 and 1972-73. These observations coincide with Moen and Severinghaus' (1981) findings on the annual weight cycle in whitetails. He found males to attain maximum weights prior to the rut and minimums in March prior to green-up. The small body size and limited fat reserves characteristic of pre-winter fawns contributed to their vulnerability to severe winter conditions; adult does' energy demands were greatest during summer lactation.

Runge and Wobeser (1975) examined 119 deer found dead throughout Saskatchewan in the winter of 1973-74. Starvation was the cause of mortality in about 33% of the cases. Femur marrow fat levels had declined to less than 1% in 18 of the 22 starved fawns, and the highest level of femur marrow fat among these starved fawns was under 9%. Of the 5 adult females and 14 adult males dying from starvation, all had femur marrow fat percentages below 1%. Sixty per cent of the fawns, 52% of the adult males, and 23% of the adult female deer examined during February and March of 1974 had femur marrow fat percentages below 1%. The 1974 winter should be regarded as abnormal, and the results a documentation of the effects of a severe winter can have on deer. The rate of kidney fat depletion through the early part of winter may serve as an excellent indicator of a potential problem, while femur marrow fats may be used to reveal the degree of severity.

However, as Karns (pers. comm., Minn. Dept. of Nat. Res., Grand Rapids, Minn.) reported, no one has performed marrow biopsies to see if surviving deer didn't reach a similar plane and recover. Adult male and female animals had percentages of 42.7% and 69.9% respectively in April 1970. A dead deer survey conducted over a small portion (1.3 km^2) of the survey block in that year resulted in an estimated mortality rate of 48%; the estimated mortality was 40% during 1971 and 36% during the severe 1974 winter (Table 3).

During 1969-70, leaf fall was early and 244 days expired prior to leaf flush, which was 25 days longer than the eight-year average. Snow depth and wind chill were both moderate in 1970, except for March, which was a relatively severe month. Snowfall was more than twice the ten-year mean and the monthly mean temperature was 4.4° Celcius below normal. For most years, March represented a moderating influence on both temperature and snowfall. Berg (1975)

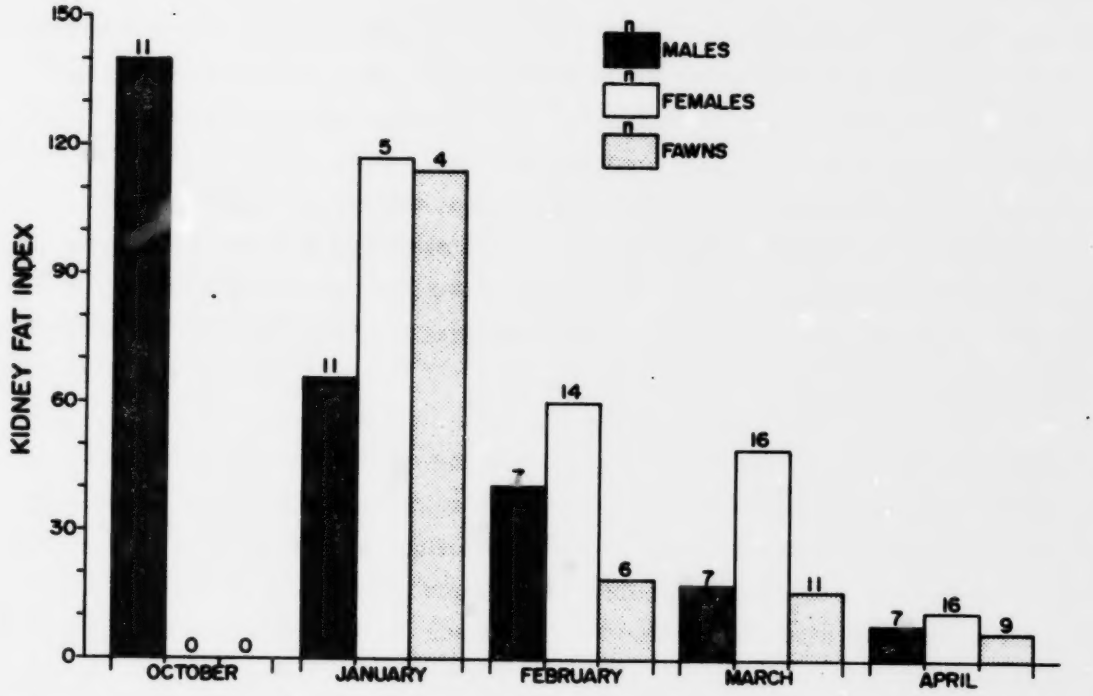

Figure 5a. Monthly kidney fat indices for deer collected during the winters 1969-70 to 1972-73.

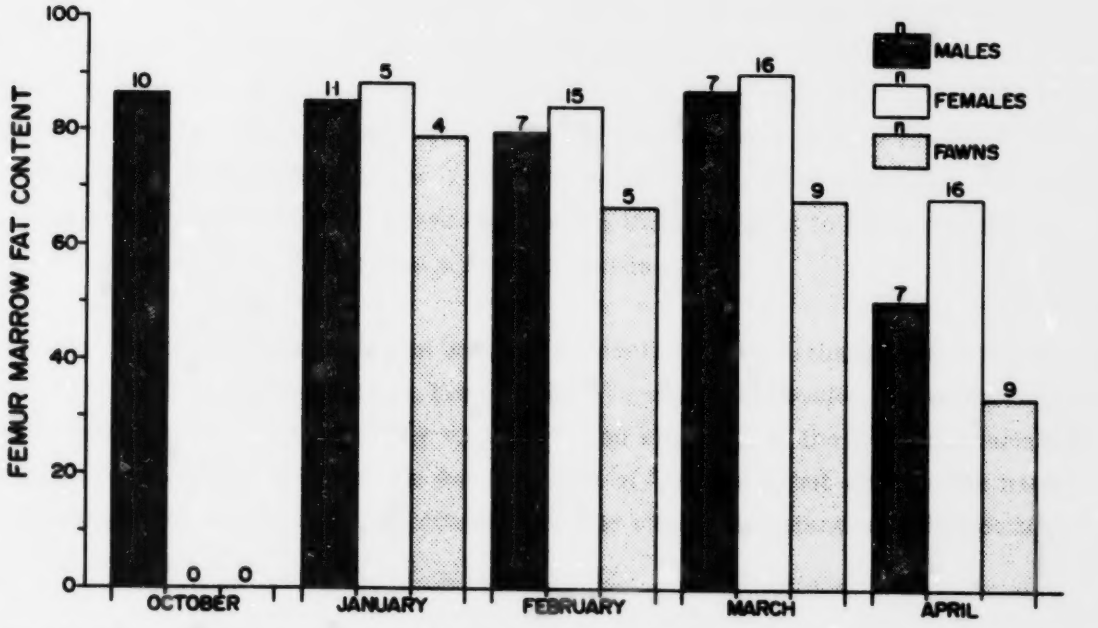

Figure 5b. Femur marrow fat content for deer collected during the winters 1969-70 to 1972-73.

believed a late winter (March) storm was a major cause of moose mortality in Minnesota in 1974. Moen (1973) stated, "Continued cold weather in the spring may have a greater effect on the energy requirements for homeothermy than the same kind of weather would have had earlier. Deer show an increase in metabolic rate in the spring, they molt, third trimester of pregnancy begins to increase nutritive requirements, and body reserves are at a low point." Femur marrow fat percentages between January and mid-March for 1970-73 averaged 86%, 92% and 90% for fawns, adult females and adult males, respectively. Mean values observed from animals collected from mid-March to mid-April were 31%, 68% and 52% for the same sex and age classes (Figure 5b).

The relationship between deer winter mortality, population density and winter severity (wind chill, snow depth, duration) was investigated. Fluctuations of annual indices of wind chill, snow depth and energy are presented in Appendix 1. Each of these variables has been reported to have some effect on condition and/or mortality of wintering ungulates in general and white-tailed deer in particular (Moen 1973). Spearman rank correlations were used to test for associations between observed mortality and density and indices of severity for wind chill, snow depth, and energy influences. A positive significant association was demonstrated only between mortality and the calculated energy index ($r = 0.754$, $p > 0.05$). The use of energy indices based on plant phenology has also been implemented by Verme and Ozoga (1980). They developed an index based on the availability of selected forbs during the autumn and spring periods which would more accurately reflect bioenergetics of white-tailed deer. Their data was collected by observation rather than by estimation techniques utilizing meteorological records. The variability in cold hardiness of many forbs combined with the cosmopolitan feeding behaviour of white-tailed deer would definitely result in a more advantageous bioenergetic profile than estimated by this investigation. The severity indices therefore tend to reflect relative differences between years rather than a detailed profile.

Extremes of either snow depth or wind chill are known to be devastating to wintering deer populations (Runge and Wobeser 1975, Verme 1968). Verme (1968) developed a winter severity index for Michigan deer, incorporating snow depth and wind chill as the two main variables responsible for condition stresses. He was confident of his results, but stressed the importance of how existing weather patterns, together with other vital circumstances, influence the welfare of northern deer.

Winter severity and summer range conditions were also considered to be important influences on white-tailed deer productivity in Manitoba (Ransom 1967). During the three years productivity was considered for the current investigation, annual variation was evident for both pregnancy

rates and ova loss (Table 7). The number of viable embryos/adult doe ranged from 1.9 in 1973 to 2.1 in 1972 similar to the range of 2.0 to 2.2 reported by Hall (1973) over a five-year period in Alberta. However, among fawns the five-year mean was 1.1 fetuses/doe in Alberta compared to only one fetus/nine fawns from the present study.

An interesting aspect of the data presented on white-tailed deer productivity on the study area was the high ova loss (20.8%) recorded in 1972 (Table 7). The growing season the previous summer (1971) was of adequate duration (May 8 to October 11), but snow and wind conditions were relatively severe December through March (Appendix 1).

Hall (1973) believed the April-May period to be most critical for the survival of late-term fetuses and newborn fawns in Alberta. During one winter in Alberta followed by a particularly severe spring only 36% of the potential 1.6 fetuses/doe survived compared to a mild winter after which 61% of the potential 1.7 fetuses/doe lived. Verme (1980) postulated that a poor nutritional plane of does during the rut would result in reduced reproductive capacity based on phenological data he had collected. Most Saskatchewan specimens were collected at least 60 days prior to parturition and it was therefore felt that productivity would be significantly further reduced in terms of live robust fawns.

Table 7. Summary of reproductive effort of female white-tailed deer from the study area (1970, 1972, 1973).

Year	Age Class	Number of Does	Pregnancy Rate (%)	Number of Corpora lutea	Number of Embryos	Number of Viable Embryos	Viable Embryos Per Pregnant Doe	Ova Loss (%)
1970	Fawn	2	0.0	0	0	0	0.0	0.0
	Yearling	1	100.0	2	1	1	1.0	50.0
	Adult	16	100.0	34	33	33	2.1	2.9
	Total	19	89.5	36	34	34	1.8	5.6
1972	Fawn	6	33.3	3	2	1	0.5	66.7
	Yearling	3	100.0	8	8	8	2.7	0.0
	Adult	12	91.7	32	28	25	2.1	21.9
	Total	21	76.2	43	38	34	1.6	20.8
1973	Fawn	1	0.0	NA*	0	0	0.0	NA
	Yearling	3	100.0	NA	6	6	2.0	NA
	Adult	15	100.0	NA	29	29	1.9	NA
	Total	19	94.7	NA	35	35	1.8	NA

* NA - data not available, as corpora lutea were not recorded.

SUMMARY AND CONCLUSIONS

1. The CBGP functions as both a production and wintering area for white-tailed deer. The value of the preserve as a wintering area is supported by the large population of deer observed during winter months; however, just under half of the winter population appears to be resident animals. Interpretation of the movement data resulted in the conclusion that emigration was generally characteristic of the fawn and yearling cohorts; adults were not observed to be involved in long distance movement. A large proportion (30%) of the emigrating component was involved in long-range movements (> 50 km) from the site of tagging. It is believed therefore that the CBGP is utilized by a significant resident population. Seasonal density estimate variations are influenced by the effects of both recruitment and an autumn immigration to the Preserve by animals in close proximity (only 1 of 19 recovered adults was more than 5 km from the CBGP when killed). The importance of the preserve as a production unit for white-tailed deer must be emphasized in any management plans, and it is highly likely that other sandhill complexes in the province could be managed on a similar basis.

   This investigation failed to resolve the extent to which surrounding summer habitat was utilized by deer or to document that deer from the CBGP migrated to and from distinct summer and winter ranges.

2. The Crystal Beach Game Preserve is but one of several sandhill complexes found within the Dark Brown Soil Zone which exist as islands of wildlife habitat surrounded by extensive, cultivated agricultural holdings. These complexes which include Manito, Duperow, Dundurn, Elbow, Cabri, Burstall, Val Jean, Swanson, Montrose and the Great Sandhills have all been identified as critical winter habitat for white-tailed deer. They comprise 2 150 km^2 and are known to winter a minimum of 3 500 white-tailed deer.

   The vegetation regimes within all the complexes are similar, therefore food utilization by white-tailed deer on these lands would likely resemble that observed on the CBGP where deer were highly dependent upon browse during the period of winter confinement. Chokecherry was the most utilized and second most abundant browse species on the study area. In excess of 55% was classed as severely hedged during browse surveys conducted in 1971. Juniper, snowberry, bearberry, and rose were also important components of the

overwinter deer diet and all were common on the study area. Following snow melt in early spring, a gradual shift from native to agriculture-related food items was initiated; cereal grains and forages were both commonly utilized. During green-up, cereal crops and other grasses frequented the rumen contents of deer.

3. Population estimates have been highly variable both between surveys conducted within years, and between those conducted in different years; mortality estimates have fluctuated widely between years. In most instances the data appears adequate to reflect trend changes for both estimates; however, accuracy of aerial surveys are known to be influenced by several factors including snow cover, weather, observer fatigue, terrain, and timing of surveys. Mortality estimates based on systematic annual ground searches for carcasses may be subject to bias depending on the pattern of the winter. High snow depths during early and mid-winter may precipitate early mortality among juvenile deer and result in a higher mortality estimate on the CBGP than would be obtained during severe late winter conditions. Younger animals may leave the CBGP during a moderation in mid-winter and thus not remain on the study area during the period when deer mortality is expected to be high; the result would be a reduction in estimate of true mortality.

4. During all winters in Saskatchewan, the body condition of white-tailed deer declines, but the rate and extent of declines are valuable in monitoring winter severity. During the years of this investigation, fawn deer collected from the study area rarely had femur marrow fat percentages below 25%, a level below which survival may be questionable. In a 1973-74 study conducted on winter-killed deer, femur marrow fat percentages as low as one per cent were prevalent. As observed in most other investigations, fawns appeared most vulnerable to severe conditions and adult females least vulnerable.

5. The factors contributing to variation in productivity were not well documented and remain uncertain; however, a high incidence of ova loss was reported following the severe 1971-72 winter, and it was believed that length of confinement and severe mid-winter weather may have contributed to the results. Three years of data on productivity is an insufficient base on which to develop conclusions.

RECOMMENDATIONS

The protection of lands recognized as the best deer habitat within the Province has been an important objective of the provincial wildlife agency for several years. Despite the concern, large scale land development projects have significantly reduced the quantity of habitat suitable to sustain and produce white-tailed deer. As this practice continues, existing blocks of good wildlife habitat become more valuable to wildlife, but unfortunately, they also become more valuable to the land developer. The Crystal Beach Game Preserve is among the premier deer habitats within the province, and its status as a "Game Preserve" is obviously in recognition of this. Action should be taken to ensure this valuable area of deer habitat maintains its capability to both sustain and produce white-tailed deer.

1. Management of the Crystal Beach Game Preserve would be enhanced by bringing the area under the jurisdiction of the Department of Parks and Renewable Resources to be managed as wildlife lands with emphasis on the production of white-tailed deer but also recognizing other species such as sharp-tailed grouse, mule deer and a large variety of non-game animals.

   The CBGP is an island of excellent wildlife habitat, and given its proximity to Saskatoon, an intensive management program should be implemented to optimize the production of white-tailed deer. To accomplish this, it is necessary to address the basic ecological requirements of the species. White-tailed deer does should enter oestrus (mid-November) in excellent physiological condition to ensure high conception rates and to provide for the necessary metabolic (fat) reserves to assist them during the winter months. Excellent summer range should abound in diverse grasses and forbs, while ideal fall ranges would consist of an abundance of fruits and twigs of palatable browse species. The high energy requirement by does during the last trimester of pregnancy (mid-March to mid-June) also demands a high plane of nutrition to ensure normal in-utero development of fetuses and to reduce the incidence of post-partum loss. Management plans should ensure maintenance of the interspersion of agricultural and native lands would be beneficial to the deer population.

   The presence of agricultural cereal grain crops in close proximity to native habitat within the CBGP has a positive impact for deer by providing a high quality diet during late winter and early spring. Planting of forage crops throughout selected areas of the CBGP would enhance the quality of the fall habitat to encourage healthy pre-rut and pre-winter condition of animals. In addition, policy should be adopted to supplement winter diets during abnormally severe and long winters to reduce mortality and maintain animal

condition up to the period of winter break-up. The adoption of a production based management plan would result in a maximum yield of animals annually to occupy surrounding habitats and thus be available for harvest.

2. Habitat units bio-physically analogous to the CBGP should be documented and investigated with respect to their potential as production areas for white-tailed deer. Selected experimental areas should be established and managed as has been recommended for the CBGP to evaluate the applicability of the production unit concept.

3. The proximity of the CBGP to Saskatoon enhances its potential value as an educational and nature interpretive site to assist students and the general public in understanding the relationships between wildlife species and their habitats. A simple design of an interpretive station and a series of foot trails through pertinent habitat types would provide excellent insight into these interrelationships.

4. Research efforts should be continued and directed toward a better awareness of herd population dynamics within the production unit and the fate of emigrating deer. The wide pattern of distribution observed for deer from the CBGP has not been documented elsewhere in North America, but very well may be common behaviour for deer occupying these island-type habitats. This knowledge is important if deer are to be managed on a production unit basis.

5. A plant phenological monitoring system should be developed, keyed on these grasses, forbs and shrubs important to white-tailed deer during the autumn and spring. Routine observation would provide a realistic appraisal of white-tailed deer bioenergetics.

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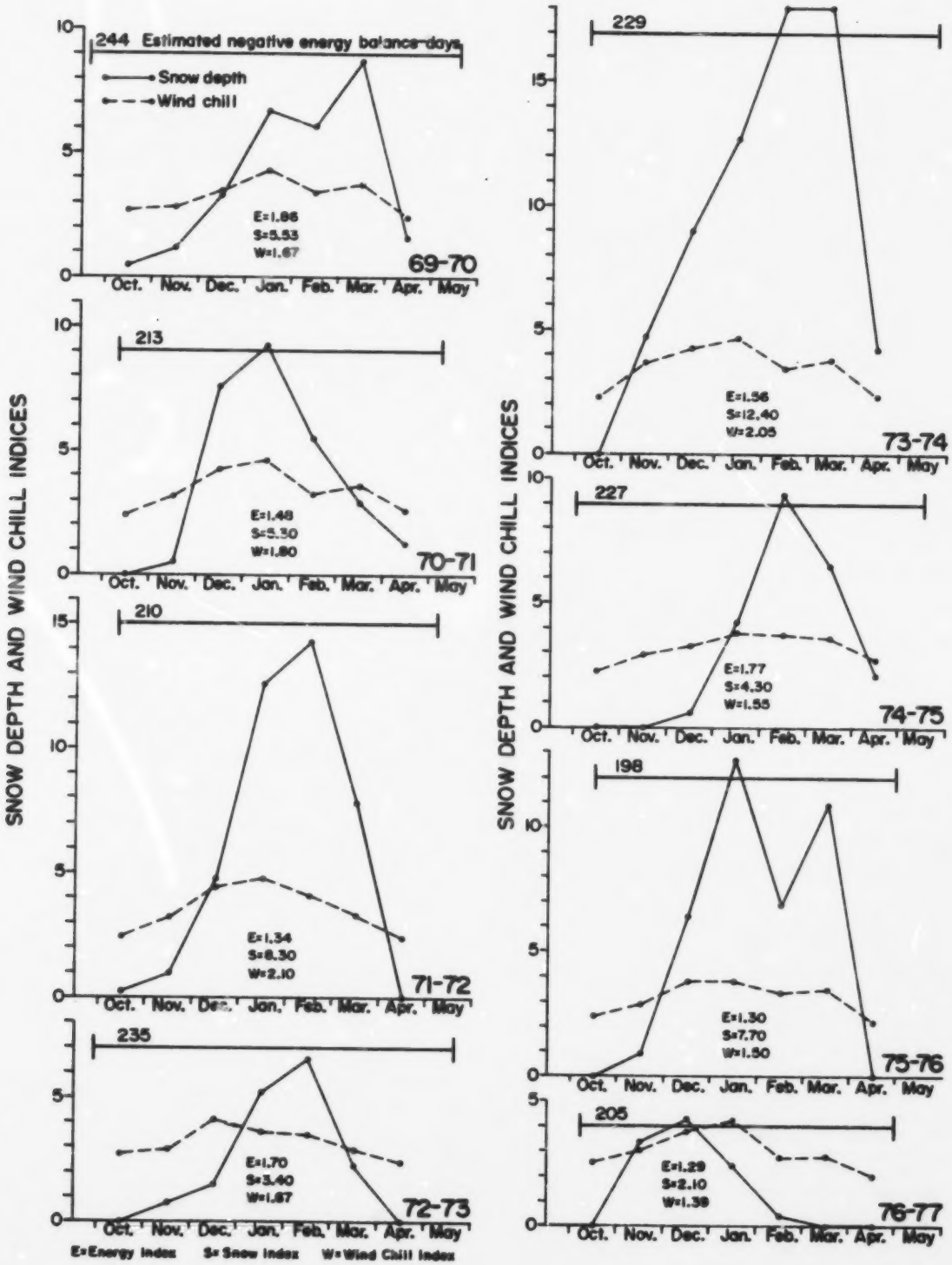
Appendix I. Average monthly snow depth, wind chill and energy indices, and the estimated duration of annual negative energy periods for deer on the study area (1969-1977).



Appendix 2. Summary of seasonal food selection by white-tailed deer from the study area (February 1970 to April 1973) based on analysis of rumen contents.

	% composition by aggregate dry weight / frequency occurrence			
	AUTUMN n=11	WINTER n=33	BREAK-UP n=25	GREEN-UP n=26
Aspen poplar *(Populus tremuloides)*	0.68/5	8.40/31	7.99/25	6.38/17
Bearberry *(Arctostaphylos uva-ursi)*	TR/3	9.39/15	11.29/21	2.78/22
Chokecherry *(Prunus virginiana)*	56.03/7	19.64/27	27.12/22	0.29/7
Currant *(Ribes spp.)*	-	TR/1	-	-
Green elder *(Alnus crispa)*	-	TR/1	-	-
Juniper *(Juniperus spp.)*	0.08/1	13.48/28	13.87/25	11.98/22
Meadowsweet *(Spirea spp.)*	-	0.12/1	-	-
Red osier *(Cornus stolonifera)*	-	8.11/21	-	-
Rose *(Rosa spp.)*	14.66/11	6.72/17	1.08/14	0.17/12
Saskatoon *(Amelanchier alnifolia)*	-	0.44/9	2.14/7	0.64/8
Silverberry *(Elaeagnus commutata)*	9.28/8	8.66/23	2.42/13	0.19/11
Western snowberry *(Symphoricarpos occidentalis)*	5.78/8	12.45/26	5.05/21	0.48/11
Wild red raspberry *(Rubus strigosus)*	TR/1	-	-	-
Willow *(Salix spp.)*	TR/2	0.33/1	0.45/4	TR/1
Unidentified browse	0.98/5	8.03/19	12.85/12	1.21/11
TOTAL BROWSE	87.49/11	95.77/34	84.26/26	24.12/25
Alfalfa *(Medicago spp.)*	1.32/4	0.65/1	0.84/4	-
Barley *(Hordeum spp.)*	TR/1	-	3.95/5	2.45/2
Foxtail *(Setaria spp.)*	-	TR/1	-	-
Oats *(Avena sativa)*	0.69/1	0.47/1	-	-
Sweet clover *(Melilotus spp.)*	-	0.38/11	TR/1	-
Wheat *(Triticum aestivum)*	0.28/3	TR/1	8.01/8	30.34/15
Wild Oats *(Avena fatua)*	-	-	0.05/2	-
Unidentified grasses *(Gramineae)*	7.35/10	0.32/22	1.64/16	37.06/15
TOTAL GRASSES and AGRICULTURAL CROPS	9.64/11	1.82/23	14.49/24	69.85/25
Blue lettuce *(Lactuca pulchella)*	-	-	TR/1	-
Fleabane *(Erigeron spp.)*	0.56/2	0.36/3	TR/3	-
Goldenrod *(Solidago spp.)*	-	0.07/1	TR/1	-
Horsetail *(Equisetum spp.)*	TR/2	TR/1	0.16/3	3.53/2
Indian paintbrush *(Castilleja spp.)*	-	TR/1	-	-
Lamb's quarters *(Chenopodium album)*	0.27/2	TR/1	-	-
Mushroom *(Basiolomycetes)*	0.13/2	-	TR/2	1.92/2
Pasture sage *(Artemisia frigida)*	-	0.17/2	TR/1	TR/1
Prairie crocus *(Anemone patens)*	-	-	TR/1	-
Thistle *(Cirsium spp.)*	TR/1	TR/1	-	-
Vetch *(Vicia spp.)*	0.10/1	-	-	-
Wild licorice *(Glycyrrhiza lepidota)*	-	1.01/1	-	-
Unidentified forbs and non-seed plants	1.77/7	0.43/20	0.83/3	0.49/12
TOTAL FORBS and NON-SEED PLANTS	2.83/8	2.04/22	0.99/20	5.94/15
TOTAL FOOD ITEMS	99.96/11	99.63/33	99.74/25	99.91/26

TR= items less than 0.05% dry weight